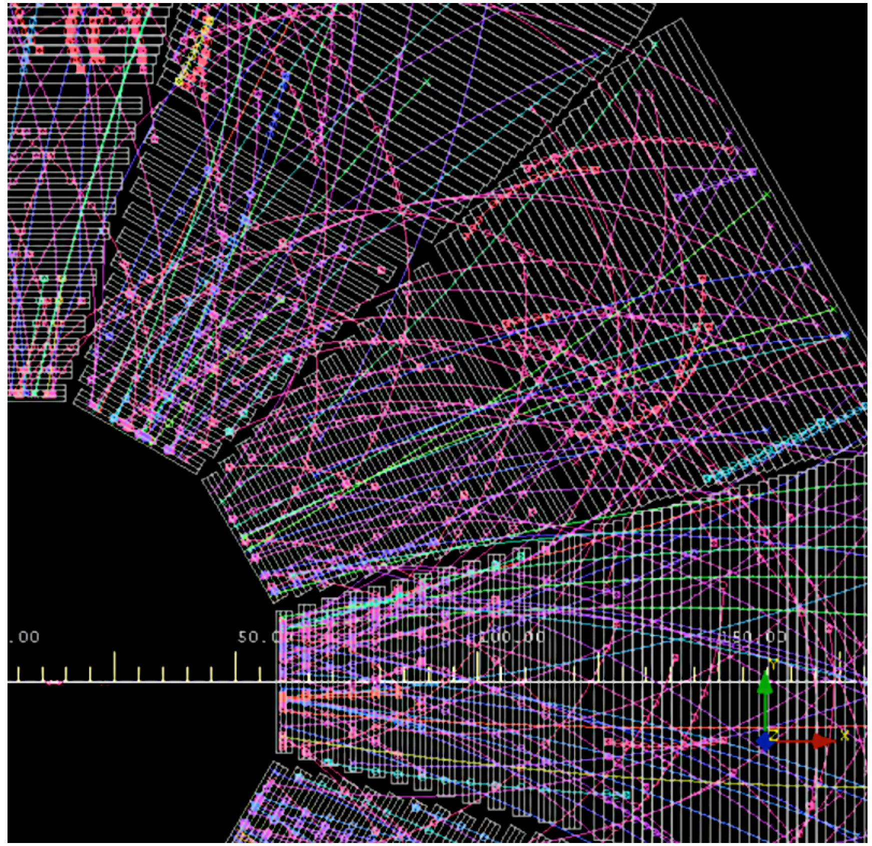

STAR Tracking Summary

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Packages in Tracking

- Seed finders
  - TPT: port of NA49's using conformal mapping within TPC
  - Sti: follow-the-track inward using global coordinates
  - CA (cellular automata): parallel-izable
  - KNN: nearest-neighbor search

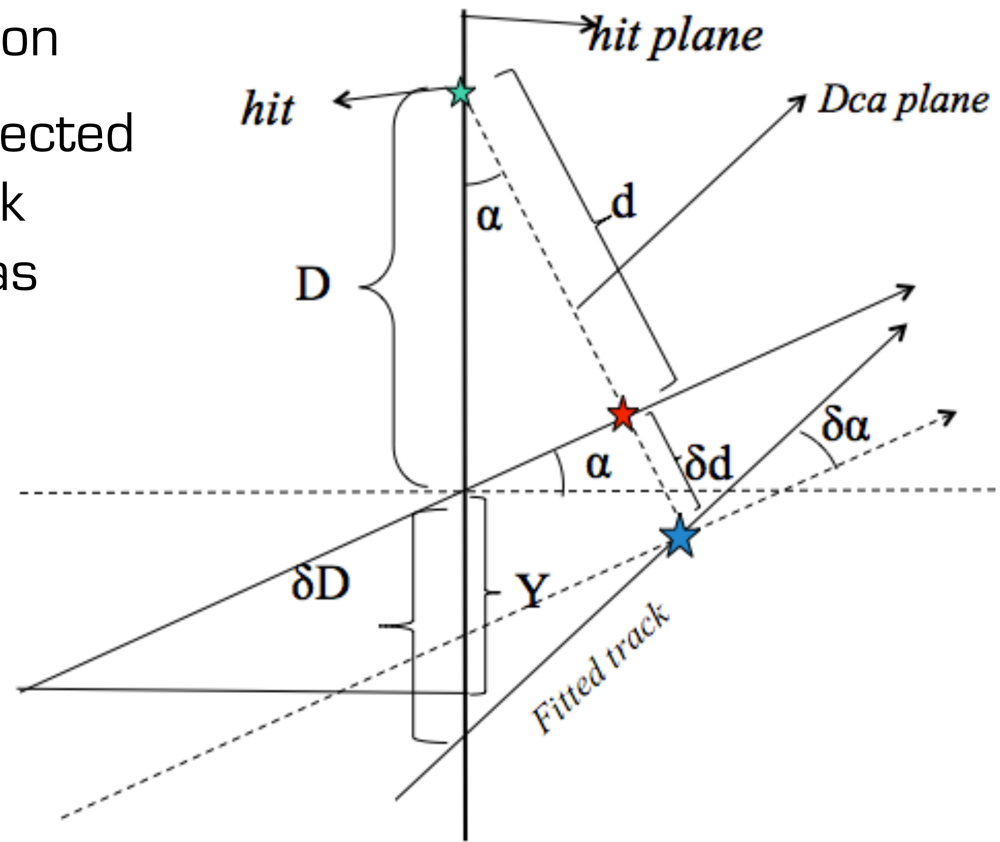
- Kalman-based track fitters
  - EGR: port of NA49's global refit code for TPC
  - Sti: attempt at developing a fast, but detector-independent tracker
  - Stv: further detector independence and avoidance of custom geometries for tracking

Sti (Integrated Tracker)

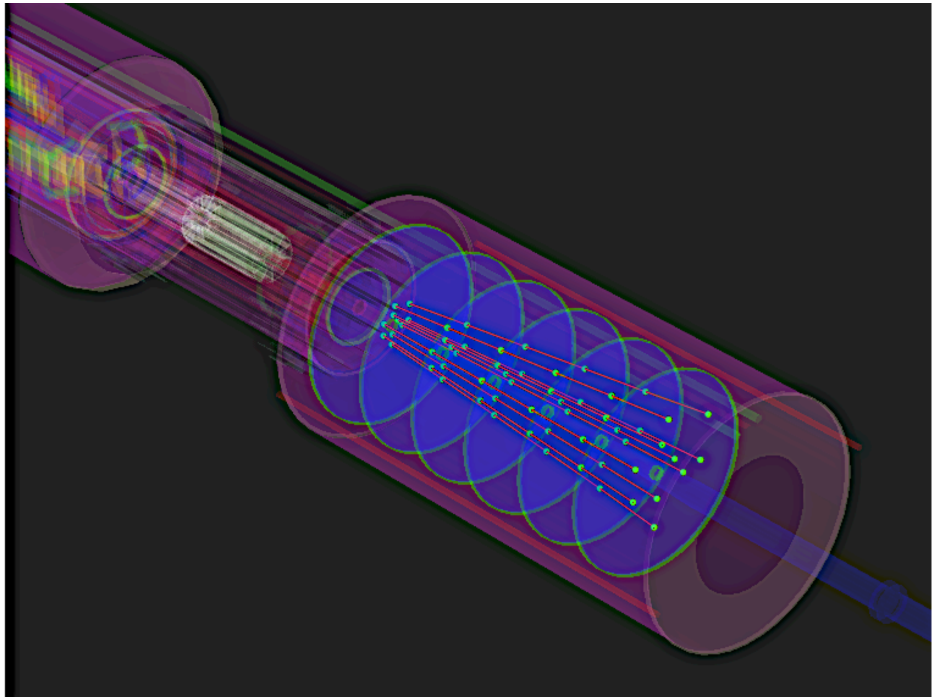
- Initial attempt (early 2000's) to provide a tracker that could handle any detector type…
  …but realities of speed issues forced scaled back goals
- Custom (Sti-specific) geometry with limited volume types and orientations specific to barrel-like detectors (including STAR's TPC, SSD, SVT)
  - Also works for HFT (PXL+IST+SSD) detectors, but extra attention and care was needed with Sti versions of HFT detector geometries to ensure sufficient performance (**PoS VERTEX2015 (2015) 013; J. Webb, CHEP 2016**)
- Restricted magnetic field orientation (along z-axis)
- Hit re-use policies:
  - Currently not allowing re-use of TPC hits to avoid track cloning (may benefit from further study)
  - HFT hit re-use has been shown to provide benefit
- Embarrassingly parallel reconstruction (one job = one CPU core) would be difficult to beat for efficient use of computing farm (Amdahl's Law)

Stv (VMC Tracker)

- Trade some speed for potential gains in **accuracy** and **ease of maintenance**
- Full geometry representation (based on GEANT geometry directly) using ROOT/TGeo (no custom geometry)
- Off-the-shelf (GEANT) track propagator
- Arbitrary magnetic field orientation
- Fits are done with hit errors projected to a plane orthogonal to the track instead of in the detector plane as is done in Sti
  - Allows arbitrary detector orientation,
    e.g. forward tracking



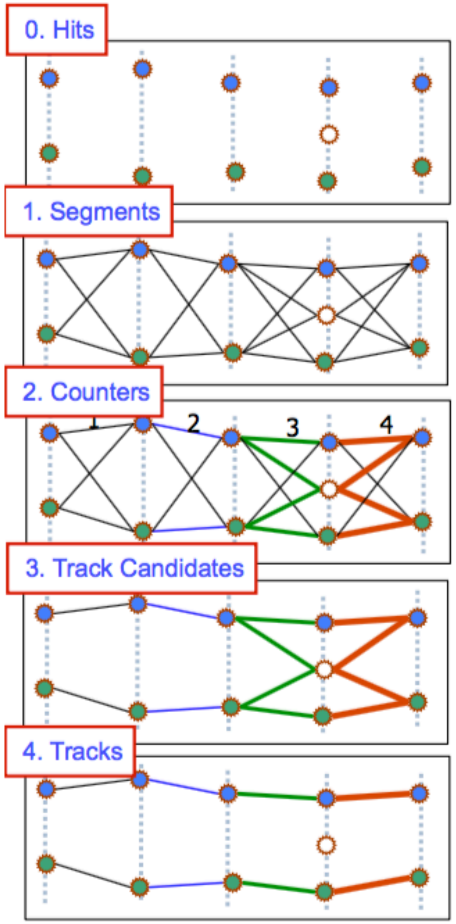
Stv status



- Able to match accuracy of Sti for existing geometries
- Successfully used for STAR studies of possible forward tracking projects
  (not possible with Sti)
- Still nearly twice as slow
  - Stv spends significantly more time navigating tracks through the geometry
  - May be addressable through numerous small parameter tweaks, and/or re-working code to more fully utilize vectorized math, and/or simplification of the geometry model

Cellular Automata

- Highly parallel-izable
- Particularly useful for HLT where **speed** trumps both accuracy and fully maximizing the efficiency of resource utilization (i.e. just throw more processor cores at the task)
  - Output seeds are generally full TPC tracks that can be fit (e.g. Kalman), but not highly accurate (e.g. no accounting of energy loss)
- Resources:
  - (**Advances in tracking and trigger concepts, I. Kisel, Journal of Physics: Conference Series 523 (2014) 012022**)
  - FCTTC workshops (https://indico.gsi.de/conferenceDisplay.py?confId=2715)

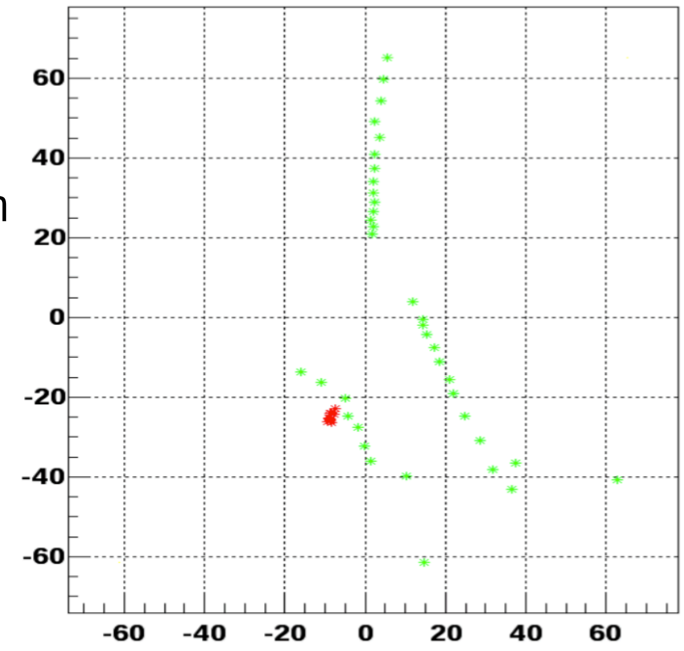


StiCA

- CA + Sti:
  - Run CA as an initial seed finder
  - Run Sti seed finder on remaining unused hits to recover some additional **efficiency**
  - Run Sti fitter (includes materials) for **accuracy**
- Re-use of hits at seed-finding stage, but re-use is eliminated before the fitting stage
  - Highest quality (longest) tracks get hit priority
    - Remaining track stubs may survive to be fit, or may be too short and die
- More stable efficiency with respect to occupancy (luminosity)

KNN

- Based on K-nearest-neighbor approach (**https://en.wikipedia.org/wiki/K-nearest_neighbors_algorithm**)
  - Hit neighbors (density) determined in projection from transverse radially outermost hits back towards (0,0,0) as most probable origin
- Hoped that it would be faster than Sti's seed finder
  - Sti starts many seeds that are eventually aborted (about 90%)
  - KNN spends considerably longer per track seed, but many more of these are kept (about 70% in our tests)
- Efficiency impacted by ordering of outermost hits
- Reduced efficiency and speed vs. Sti remain open issues
  - Potentially addressable through numerous small parameter tweaks while balancing speed vs. efficiency



Summary

- Choice of tracking depends on what aspects are most important
  - Sti is a balanced solution that has been used for a decade to produce high quality physics results for large productions with finite resources
    - Maintenance of geometries remains an issue and required notable attention for the HFT program
    - Sti geometries are too limited for forward tracking
  - StiCA coming into more use
    - Higher efficiencies with only marginal effects on speed
    - Does not address shortcomings of Sti
  - CA used by itself for HLT where parallel-izable speed is king
  - Stv is in our pocket if & when physics demands it
- Flexibility to run other, or even multiple seed finders